DOCUMENT RESUME

ED 093 686 SE 018 006

AUTHOR	Reynard, Dale C.
TITLE	Computer Programs for Chemistry Experiments I and II.
INSTITUTION	Delaware State Dept. of Public Instruction, Dover.; Del Mod System, Dover, Del.
SPONS AGENCY	National Science Foundation, Washington, D.C.
REPORT NO	NSF-GW-6703
PUB DATE	24 Sep 73
NOTE	50p.; Not available in hardcopy due to marginal legibility of original document
AVAILABLE FROM	Mr. John F. Reiher, State Supervisor of Science and Environmental Education, Department of Public Instruction, John G. Townsend Building, Dover, Delaware 19901 ($1.00, make checks payable to the Del Mod System)
EDRS PRICE	MF-$0.75 HC Not Available from EDRS. PLUS POSTAGE
DESCRIPTORS	*Chemistry; *Computer Assisted Instruction; Curriculum Guides; Instruction; *Instructional Materials; Science Education; *Secondary School Science; *Teaching Guides; Units of Study (Subject Fields)
IDENTIFIERS	*Del Mod System

ABSTRACT

This unit of instruction includes nine laboratory experiments. All of the experiments are from the D.C. Health Revision of the Chemical Education Materials Study (CHEMS) with one exception. Program six is the lab from the original version of the CHEMS program. Each program consists of three parts (1) the lab and computer hints, (2) the description of a sample run, and (3) the actual sample run. The programs may be used as a check for actual student calculations or where the mathematics seems extremely difficult, for running the actual program. To use these programs with understanding, suggested reference materials are listed. A cross reference list for each of the programs is included in the manual indicating the code, the Health curriculum lab number and the Freeman lab number. Concepts covered include: (1) Masses of Equal Volumes of Gases, (2) Cooper-Silver Nitrate Reaction, (3) Conservation of Mass, (4) Formula of a Hydrate, (5) Reaction of Magnesium Equilibrium, (8) Acid-Base Titration, and (9) Molar Concepts. (EB)

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COMPUTER PROGRAMS FOR CHEMISTRY EXPERIMENTS

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COMPUTER PROGRAMS FOR CHEMISTRY EXPERIMENTS I AND II

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September 24, 1973

Printed and disseminated through the office of the Del Mod Component Coordinator for the State Department of Public Instruction, John G. Townsend Building, Dover, Delaware 19901

Preparation of this monograph was supported by the National Science Foundation Grant No. G.W. 6703 to the Del Mod System, P. O. Box 192, Dover, Delaware 19901

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COMPUTER PROGRAMS FOR CHEMISTRY EXPERIMENTS 1

BY DALE REYNARD

(A DEL-MOD FUNDED PROJECT)
JUNE 15, 1972

EDITED AND PREPARED BY DSAA: PROJECT DELTA
REVISION JULY 1973

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INTRODUCTION

USAGE OF THE COMPUTER IS NO LONGER LIMITED TO BUSINESS AND INDUSTRY, BUT HAS FOUND A PLACE IN EDUCATION. THROUGH THE EFFORTS OF THE DELAWARE SCHOOL AUXILLARY ASSOCIATION AND ITS PROJECT DELTA, THE COMPUTER HAS FOUND ITS WAY INTO THE DELAWARE SCHOOL SYSTEM.

MOST OF THE PROGRAMS IN THIS MATERIAL HAVE BEEN USED BY A CLASS OF CHEMISTRY STUDENTS OR BY HUNDREDS OF CHEMISTRY STUDENTS. SOME PROGRAMS HAVE BEEN USED AT BRANDYWINE HIGH SCHOOL FOR TWO YEARS.

TO USE THESE PROGRAMS WITH UNDERSTANDING ONE SHOULD HAVE THE FOLLOWING REFERENCE MANUALS FOR ASSISTANCE:

1. LABORATORY MANUAL FOR CHAMISTRY: EXP. & PRINC. HEATH 68
2. TEACHERS LABORATORY MANUAL FOR CHEMISTRY: EXP. & PRINC.
3. TEACHERS GUIDE TO CHEMISTRY: AN EXP SCI FREEMAN 62
4. LABORATORY MANUAL FOR 63

ALL LABORATORY EXPERIMENTS ARE ACTUAL LABS FROM THE U.C. HEATH REVISION OF CHEMS WITH THE EXCEPTION OF PROGRAM 6 WHICH IS THE ACTUAL LAB FROM THE ORIGINAL VERSION OF THE CHEMS PROGRAM. EACH PROGRAM CONSISTS OF THREE PARTS. PART 1 IS THE LAB AND COMPUTER HINTS. PART 2 IS THE DESCRIPTION OF A SAMPLE RUN AND PART 3 IS THE ACTUAL SAMPLE RUN.

THE PROGRAMS MAY BE USED AS A CHECK FOR ACTUAL STUDENT CALCULATIONS OR IN SOME CASES THE MATHEMATICS SEEMS EXTREMELY DIFFICULT TO STUDENTS AND THIS CAN BE AVOIDED BY RUNNING THE ACTUAL PROGRAM. WITHOUT THE ASSISTANCE OF THE PROJECT DELTA CENTER AND ITS VERY ABLE PERSONNEL THIS SERIES OF PROGRAMS WOULD NOT BE POSSIBLE.

IT IS HOPED THAT THE PROGRAM WILL PROVIDE YOUR STUDENTS WITH A LEARNING EXPERIENCE ON THE TERMINAL.

NOTE: ALTHOUGH THESE PROGRAMS HAVE BEEN TESTED BY THE AUTHOR, NO WARRANTY, EXPRESS OR IMPLIED, IS MADE BY THE AUTHOR, OR BY DSAA: PROJECT DELTA AS TO THE ACCURACY OR FUNCTIONING OF THE PROGRAMS OR RELATED MATERIAL, AND NO RESPONSIBILITY IS ASSUMED BY THESE PARTIES IN CONNECTION THEREWITH.

GENERAL INFORMATION ABOUT THE LAB PROGRAMS

THE LAB PROGRAMS FOLLOW A GENERAL FORMAT, UNLESS OTHERWISE STATED IN THE EXPLANATION OF THE LAB. THE PROGRAM WILL FIRST PRINT THE NAME OF THE LAB AND PROVIDE SPACE FOR THE STUDENTS NAME AND SECTION NUMBER. IT WILL THEN REQUEST THE DATA COLLECTED DURING THE LAB. IF AT ANY TIME SOMETHING DOES NOT APPLY TO YOUR LAB PROCEDURE, FOR EXAMPLE YOU DID NOT USE FILTER PAPER, THEN TO THE QUESTION "ENTER MASS OF FILTER PAPER?", YOU WOULD RESPOND WITH A ZERO.

AFTER ALL THE DATA HAS BEEN ENTERED, THE RESULTS OF THE SESSION ARE PRINTED. WHENEVER POSSIBLE THE CALCULATIONS ARE PRINTED IN THE FORM OF A TABLE OR IN RESPONSE TO THE QUESTIONS IN THE LAB MANUAL. SEVERAL OF THE PROGRAMS ASK AT THE END IF THERE ARE OTHER STUDENTS WAITING TO USE THE PROGRAM, IF THE RESPONSE IS "YES" THE PROGRAM WILL RESTART.

CROSS REFERENCE LIST FOR PROGRAMS

PROGRAM TITLE	CODE	HEATH LAB NO	FREEMAN LAB NO
MASSES OF EQUAL VOLUMES OF GASES	GASEMA	5	8
CU-AGNO3 REACTION	CUAGMU	7	7
CONSERVATION OF MASS	CONMA1	8	6
FORMULA OF A HYDRATE	HYDRA3	9	66
RX OF MG WITH HCL	MGHCL1	11	4
ENERGY OF COMBUSTION(WITH CHANGES)	HEAT1	25	5
CHEMICAL EQUILIBRIUM	FESCN	29	15
ACID-BASE TITRATION	ACBA11	32	23
MOLES OF CU, MOLES OF AG, AND MOLES OF ELECTRONS DURING ELECTROLYSIS	AGMCU	38	25

MASSES OF EQUAL VOLUMES OF GASES

ONLY THREE GASES ARE USED BECAUSE OF THE TIME FACTOR. TWO OTHER GASES SUCH THAT ONE IS LIGHTER AND ONE IS HEAVIER THAN OXYGEN GAS. THE DATA FROM THE OTHER GASES MAY BE ENTERED IN PLACE OF CARBON DIOXIDE AND AMMONIA. GIVING GOOD RESULTS ARE METHANE (NATURAL GAS) AND HELIUM. STRESS TO STUDENT THAT HAVING A NEAT DATA SHEET WILL BE MOST HELPFUL FOR INTERPRETING THE DATA AND IN USING THE COMPUTER. IF A BAG IS BROKEN AT SOME TIME DURING THE LAB, THEN, THAT GROUP MUST START FROM THE BEGINNING OF THE EXPERIMENT. THIS LAB IS USUALLY DONE IN GROUPS OF TWO OR MORE. RESULTS ARE USUALLY VERY ACCURATE. IF YOU HAVE NOT EMPLOYED THIS LAB BEFORE, TRY IT AND SEE THE EXPRESSION THE STUDENTS HAVE WHEN THEY WEIGH THE BAG OF GAS OF AMMONIA.

DESCRIPTION OF GASER4

GASER4 BEGINS BY ASKING FOR SOME PRELIMINARY INFORMATION. IT WILL REQUEST THE NUMBER OF GASES USED AND THE NAMES OF THE GASES. THE FIRST NAME REQUESTED IS THAT OF THE CONTROL. THIS IS NEEDED FOR THE RATIOS THAT ARE GIVEN AT THE END OF THE SESSION.

GASER4 THEN REQUESTS THE LAB DATA. ALL DATA IS ENTERED IN MILLILITERS AND GRAMS. THE FOLLOWING INFORMATION IS NEEDED:

MASS OF EMPTY BAG ASSEMBLY
MASS OF ASSEMBLY AND EACH GAS USED
VOLUME OF THE BAG WHEN FILLED WITH AIR
VALUE FROM TABLE FOR MASS OF 1 LITER OF AIR

THE FOLLOWING RESULTS ARE GIVEN:

APPARENT MASS OF EACH GAS
MASS OF AIR DISPLACED BY BAG
ACTUAL MASS OF EACH GAS
RATIOS OF THE MASSES OF EACH GAS TO THE CONTROL GAS

SAMPLE RUN OF GASER4

```
GASER4  03:24 PM          18-JUL-73
MASSES OF EQUAL VOLUMES OF GASES

NAME                              SECTION

PRELIMINARY INFORMATION

HOW MANY DIFFERENT GASES DID YOU USE? 3
NAME OF GAS 1 (THE CONTROL)? OXYGEN
NAME OF GAS 2 ? CARBON DIOXIDE
NAME OF GAS 3 ? AMMONIA

DATA
ALL DATA IS ENTERED IN MILLELITERS OR GRAMS.

MASS OF EMPTY BAG ASSEMBLY IS? 17.36
MASS OF ASSEMBLY AND OXYGEN GAS IS? 17.48
MASS OF ASSEMBLY AND CARBON DIOXIDE GAS IS? 17.94
MASS OF ASSEMBLY AND AMMONIA GAS IS? 17.06
VOLUME OF BAG WHEN FILLED WITH AIR IS? 755.0
VALUE FROM TABLE FOR MASS OF 1 LITER OF AIR IS? 1.12

CALCULATIONS

APPARENT MASS OF OXYGEN GAS IS .120001
APPARENT MASS OF CARBON DIOXIDE GAS IS .580002
APPARENT MASS OF AMMONIA GAS IS-.299999

MASS OF AIR DISPLACED BY BAG IS .8456

ACTUAL MASS OF OXYGEN GAS IS .965601
ACTUAL MASS OF CARBON DIOXIDE GAS IS 1.4256
ACTUAL MASS OF AMMONIA GAS IS .545601

RATIO OF MASSES OF CARBON DIOXIDE TO OXYGEN IS 1.476
RATIO OF MASSES OF AMMONIA TO OXYGEN IS .565
```

LAB AND PROGRAM HINTS — PROGRAM 2

COPPER-SILVER NITRATE REACTION (CUAGNO)

TO SPEED UP WEIGHINGS THE SILVER NITRATE IS PASSED OUT INDIVIDUALLY TO THE STUDENTS AND THEY ARE TOLD TO WEIGH OUT APPROXIMATELY 1.0 GRAMS. THEY WEIGH THE VIAL CONTAINING THE SILVER NITRATE FIRST, THEN REDUCE THE SCALE BY 1.0 GRAMS, POUR A FEW CRYSTALS IN THEIR 100 ML BEAKER. CONTINUE THIS TILL THEY HAVE A MASS NEAR 1.0 GRAMS IN THEIR BEAKER. STRESS NEAT AND ORDERLY DATA, AS THIS WILL SAVE TIME ON INTERPRETING AND ACTUAL COMPUTER TIME. RESULTS ARE USUALLY SUCH THAT THE RATIO OF MOLES OF SILVER TO COPPER WHEN ROUNDED TO NEAREST INTEGER IS 2 TO 1. VALUES FOR THE CLASS AVERAGE BETWEEN 1.811 TO 2.211.

DESCRIPTION OF CUAGNO

THE PROGRAM WILL BEGIN BY ASKING FOR THE DATA FROM THE EXPERIMENT ALL THE MASSES ARE ENTERED IN GRAMS. IT WILL ASK FOR THE FOLLOWING:

MASS OF CLEAN, DRY, 100 ML BEAKER
MASS OF VIAL, CAP, AND AGNO$_3$ BEFORE THE REACTION
MASS OF VIAL, CAP, AND AGNO$_3$ AFTER THE REACTION
MASS OF THE COPPER COIL BEFORE THE REACTION
MASS OF THE COPPER COIL AFTER THE REACTION
MASS OF 100 ML BEAKER AND SILVER CRYSTALS
MASS OF FILTER PAPER (IF USED)

IT WILL THEN GIVE YOU THE FOLLOWING RESULTS:

MASS OF COPPER USED
MOLES OF COPPER USED
MASS OF SILVER FORMED
MOLES OF SILVER FORMED
RATIO OF MOLES OF SILVER TO COPPER
MOLES OF SILVER NITRATE USED
RATIO OF MOLES OF SILVER TO SILVER NITRATE

THE PROGRAM LEAVES THE CALCULATIONS OF QUESTIONS 9 AND 10 FOR THE STUDENT TO DO.

9. HOW MANY ATOMS OF CU WERE REMOVED FROM THE WIRE USED IN THIS EXPERIMENT? (ANSWER: THE NUMBER OF MOLES OF CU IS MULTIPLIED BY 6.02E 23. THE UNITS ARE ATOMS/MOLE.)

10. HOW MANY ATOMS OF SILVER METAL WERE FORMED IN THIS EXPERIMENT? (ANSWER: THE NUMBER OF MOLES OF SILVER IS MULTIPLIED BY 6.02E 23 THE UNITS ARE ATOMS/MOLE.)

SAMPLE RUN OF CUAGNC

COPPER-SILVER NITRATE REACTION

NAME SECTION

DATA

MASS OF CLEAN,DRY 100 ML BEAKER IS	? 40
MASS OF VIAL,CAP AND SILVER NITRATE BEFORE IS	? 14
MASS OF VIAL,CAP AND SILVER NITRATE AFTER IS	? 12
MASS OF COPPER COIL BEFORE IS	? 4
MASS OF COPPER COIL AFTER IS	? 1
MASS OF 100 ML BEAKER AND SILVER CRYSTALS IS	? 60
MASS OF 1 PIECE OF FILTER PAPER IS	? .8

CALCULATIONS

MASS OF COPPER USED IS	3.2
MOLES OF COPPER USED IS	4.72E-02
MASS OF SILVER FORMED IS	19.2
MOLES OF SILVER FORMED IS	1.78E-01
RATIO OF MOLES OF SILVER TO COPPER IS	3.77
MOLES OF SILVER NITRATE USED IS	3.53E-02
RATIO OF MOLES OF SILVER TO SILVER NITRATE IS	5.04

YOU CALCULATE QUESTIONS 9 AND 10

9. HOW MANY ATOMS OF COPPER WERE REMOVED FROM THE WIRE USED IN YOUR EXPERIMENT?

10. HOW MANY ATOMS OF SILVER METAL WERE FORMED IN YOUR EXPERIMENT?

LAB AND PROGRAM HINTS PROGRAM 3

CONSERVATION OF MASS DURING A CHEMICAL CHANGE

STRESS THAT WEIGHINGS BE MADE ON THE SAME SCALES THROUGHOUT THE ENTIRE EXPERIMENT. DRYING PROCEDURES SHOULD NOT BE HASTENED. IF A STUDENT TEARS HIS FILTER PAPER, THEN THIS SHOULD BE SAVED AND ANOTHER USED. IN TYPING IN HIS DATA, THEN INCLUDE MASS OF BOTH PIECES OF FILTER PAPER. STRESS NEAT DATA SHEETS WHICH WILL MEAN LESS TIME USED WHEN ONE HAS ACCESS TO THE COMPUTER. NOTICE THE SAMPLE PROGRAM SHOWS THAT THE LAW OF CONSERVATION OF MASS WAS PROVEN BUT THE STUDENT WOULD NOT BE A GOOD PERSON TO HIRE AT THE PHILADELPHIA MINT AS THE RECOVERY OF SILVER WAS ONLY A LITTLE ABOVE 50%. FOLLOW THE TEACHERS GUIDE AND USE AMOUNTS INDICATED. USING MORE CAUSES THE DRYING TIME TO INCREASE GREATLY.

DESCRIPTION OF CONMA1

CONMA1 WILL REQUIRE THE FOLLOWING INFORMATION IN ORDER:
- MASS OF THE 100 ML BEAKER USED IN EXPERIMENT 7*
- MASS OF SILVER NITRATE USED IN EXPERIMENT 7*
- MASS OF SILVER FORMED IN EXPERIMENT 7*
  (THIS INFORMATION CAN QUICKLY BE OBTAINED FROM THE OUTPUT FROM LAB7'S CUAGMO.)

NEXT THE PROGRAM WILL NEED:
- MASS OF BEAKER #1 AND SILVER NITRATE IN PART 1
- MASS OF BEAKER #1, FILTER PAPER AND SILVER CHLORIDE
- MASS OF BEAKER #2
- MASS OF PIECE OF FILTER PAPER USED
  (IF NO FILTER PAPER WAS USED THE STUDENT SHOULD ENTER A MASS OF 3 GRAMS.)
- MASS OF BEAKER 2 AND THE SOLID RESIDUE
- MASS OF SODIUM CHLORIDE USED

ALL MEASUREMENTS (MASSES) ARE ENTERED IN GRAMS

ONCE ALL THIS INFORMATION HAS BEEN ENTERED, THE RESULTS WILL BE OUTPUT. THE OUTPUT INCLUDES: A TABLE CONTAINING THE MASS AND NUMBER OF MOLES OF EACH SUBSTANCE USED, THE RATIO OF MOLES OF SILVER NITRATE IN EXPERIMENT 8* TO EXPERIMENT 7*, THE RATIO OF PRODUCTS MASSES TO REACTANTS MASSES, RATIOS OF SILVER TO SILVER NITRATE AND SILVER CHLORIDE, AND FINALLY THE PERCENTAGE OF SILVER RECLAIMED.

* EXPERIMENT 8 CONSERVATION OF MASS DURING A CHEMICAL CHANGE
* EXPERIMENT 7 COPPER-SILVER NITRATE REACTION

SAMPLE RUN OF CONMAT

NAME SECTION

CONSERVATION OF MASS IN A CHEMICAL CHANGE

DATA

MASS OF 100 ML BKR IN EXP 7 IS ? 50.64
MASS OF SILVER NITRATE USED IN EXP 7 IS ? 5.76
MASS OF SILVER FORMED IN EXP 7 IS ? 2.54
MASS OF BKR #1 AND SILVER NITRATE IN PT 7 IS ? 55.25
MASS OF BKR 1,FILTER PAPER AND AGCL IS ? 53.81
MASS OF BKR #2 IS ? 96.22
MASS OF 1 PIECE OF FILTER PAPER IS ? .57
MASS OF BKR 2 AND SOLID RESIDUE IS ? 100.23
MASS OF SODIUM CHLORIDE USED IS ? 2.00

CALCULATIONS

QUESTION 1 AND TABLES AS FOLLOWS:

QUANTITY	MASS	MOLES
SILVER, EXP 7	2.54	.2353035E-1
SILVER NITRATE, EXP 7	5.76	.3386245E-1
SILVER NITRATE EXP8	4.62	.2717865E-1
SODIUM CHLORIDE USED	2	.3496554E-2
SILVER CHLORIDE,BKR 1	2.61	.1821354E-1
RESIDUE IN BKR 2	0.25	

QUESTION 2
MOLES OF SILVER NITRATE(8) TO SILVER NITRATE(7) IS .802894

QUESTION 3
MASS OF PRODUCTS TO MASS OF REACTANTS IS 1.03625

QUESTION 4
RATIO OF MOLES OF SILVER TO SILVER NITRATE IS 1
RATIO OF MOLES OF SILVER TO SILVER CHLORIDE IS 1

QUESTION 5
% SILVER RECLAIMED IS 53.7553

ARE STUDENTS WAITING TO USE THIS PROGRAM (YES OR NO)? NO

LAB AND PROGRAM HINTS PROGRAM 4

FORMULA OF A HYDRATE (HYDRA3)

BE CERTAIN TO GIVE THE STUDENTS THE MASS OF THE ANHYDROUS SALT PER MOLE. FROM PAST EXPERIENCE THE FOLLOWING SALTS GIVE VERY GOOD RESULTS IF LAB DIRECTIONS ARE FOLLOWED:

HYDRATE	MASS/MOLE
$BaCl_2 \cdot 2H_2O$	208.3
$MgSO_4 \cdot 7H_2O$	120.3
$Na_2CO_3 \cdot 5H_2O$	160.0
$CuSO_4 \cdot 5H_2O$	159.5
$MnSO_4 \cdot H_2O$	150.9

THE LAB IS DONE INDIVIDUALLY AND BECAUSE OF THE TIME FACTOR, IF THE STUDENTS WEIGHING AFTER HEATING VARY BY 0.02 GRAMS, THEN THEY MAY CONSIDER THE WATER OF HYDRATION TO BE DRIVEN FROM THE HYDRATE. STUDENTS SHOULD BE AWARE OF THE HOTTEST FLAME OF THE BUNSEN BURNER.

DESCRIPTION OF HYDRA3

THE DATA REQUIRED BY HYDRA3 IS THE FOLLOWING:

- MASS OF EMPTY CRUCIBLE AND COVER
- MASS OF CRUCIBLE, COVER AND HYDRATE
- MASS OF THE CRUCIBLE, COVER, AND HYDRATE AFTER THE FINAL HEATING
- MASS OF 1 MOLE OF ANHYDROUS SALT

THE PRECEDING ARE ENTERED IN GRAMS.

THE RESULTS ARE:

- THE MOLES OF ANHYDROUS SALT
- THE MOLES OF WATER
- THE RATIO OF THE MOLES OF WATER TO THE MOLES OF SALT
- THE EMPIRICAL FORMULA OF THE HYDRATE
  (THIS IS GIVEN AS 1 MOLE OF ANHYDROUS SALT PER SOME NUMBER OF MOLES OF WATER.)

SAMPLE RUN OF HYDRAT

FORMULA OF A HYDRATE

NAME SECTION

DATA

MASS OF EMPTY CRUCIBLE AND COVER IS ? 21.17
MASS OF CRUCIBLE, COVEN AND HYDRATE IS ? 30.73
MASS OF THE ABOVE AFTEN FINAL HEATING IS ? 29.33
MASS OF 1 MOLE OF ANHYDROUS SALT IS ? 208.3

CALCULATIONS

Q 1 MOLES OF ANHYDROUS SALT IS .3917435E-1
Q 2 MOLES OF WATER IS .7777778E-1
Q 3 RATIO OF MOLES OF WATER TO MOLES SALT IS 1.985641
Q 4 EMPIRICAL FORMULA OF YOUR HYDRATE IS 1 MOLE OF
ANHYDROUS SALT PER 2 MOLES OF WATER

ARE STUDENTS WAITING TO USE THIS PROGRAM (YES OR NO)? NO

LAB AND COMPUTER HINTS PROGRAM 5

RX OF MG WITH HCL

EACH YEAR ITS SEEMS THAT THE MAGNESIUM RIBBON IS FROM A DIFFERENT SUPPLIER AND IT IS ESSENTIAL THAT A METER LENGTH IS MEASURED AND WEIGHED PRIOR TO LAB FOR STUDENT DATA PURPOSES. THIS SHOULD BE MEASURED TO THE NEAREST THOUSANDTH OF A GRAM IF POSSIBLE. IF GAS COLLECTING TUBES ARE NOT AVAILABLE THEN BURRETS MAY BE USED WITH SOME MANIPULATIONS. STRESS THAT STUDENTS HAVE AN ORDERLY DATA SHEET SO THAT WHEN THEY HAVE ACCESS TO THE COMPUTER THAT THEY DO NOT WASTE TIME.

RESULTS OF THE LAB ARE IN CLOSE AGREEMENT WITH VALUES FOR STANDARD PRESSURE AND ROOM TEMPERATURE (SP & RT).

DESCRIPTION OF MGHCL1

THE DATA FROM THE EXPERIMENT IS ENTERED IN THE FOLLOWING ORDER:
- THE MASS OF THE MAGNESIUM RIBBON PER METER
  (THIS INFORMATION IS GIVEN TO THE STUDENTS)
- THE LENGTH OF THE MAGNESIUM RIBBON IN CM
- THE VOLUME OF THE TOTAL GASES COLLECTED IN ML
- THE TEMPERATURE OF THE WATER IN DEGREES CENTIGRADE
- THE TEMPERATURE OF THE ROOM IN DEGREES CENTIGRADE
- THE BAROMETRIC PRESSURE IN THE ROOM IN MM
- THE PRESSURE OF THE WATER
  (THIS IS OBTAINED FROM THE TABLE IN THE TEXT)

THE RESULTS ARE:
- THE MASS OF MAGNESIUM IN GRAMS
- THE NUMBER OF MOLES OF MAGNESIUM
- THE PRESSURE OF HYDROGEN GAS IN MM
- THE VOLUME OF HYDROGEN GAS IN ML AT 1 ATM PRESSURE
- THE VOLUME OF HYDROGEN GAS AT 1 ATM PRODUCED BY 1 MOLE
- THE VOLUME OF 1 MOLE OF HYDROGEN GAS AT STANDARD PRESSURE
  (SP AND ROOM TEMPERATURE (RT))
- THE MASS OF HYDROGEN GAS IN 1 LITER AT RT AND SP

SAMPLE RUN OF MGHCL1

```
RUNMGHCL1

REACTION OF MAGNESIUM WITH HYDROCHLORIC ACID

NAME                              SECTION

DATA
WHAT IS THE MASS OF THE MAGNESIUM RIBBON PER METER? .71
WHAT IS THE LENGTH OF THE MAGNESIUM RIBBON IN CM? 6.5
WHAT IS THE VOLUME OF THE TOTAL GASES COLLECTED IN ML? 47.9
WHAT IS THE TEMP OF THE WATER IN DEGREES CENTIGRADE? 27.5
WHAT IS THE TEMP OF THE ROOM IN DEGREES CENTIGRADE? 24.5
WHAT IS THE BAROMETRIC PRESSURE IN THE ROOM? 743.7
WHAT IS THE PRESSURE OF THE WATER FROM THE TABLE IN THE TEXT? 27.5

RESULTS
Q 1  MASS OF MG IN GRAM IS                          .04615
Q 2  MOLE OF MG IS                                .1899181-2
Q 3  PRESSURE OF HYDROGEN GAS IN MM IS             716.2
Q 4  VOL OF HYDROGEN GAS AT 1 ATM PRESSURE IN ML IS 46.4
Q 5  VOL OF HYDROGEN GAS AT 1 ATM PRODUCED BY 1 MOLE IS 24.4316
Q 6  VOL 1 MOLE OF HYDROGEN GAS AT SP AND RT IS 24.5 L
Q 7  MASS OF HYDROGEN GAS IN 1 LITER AT RT AND SP IS C
```

LAB AND COMPUTER HINTS PROGRAM A

ENERGY OF COMBUSTION (WITH CHANGES) (HEAT1)

THIS LAB WAS THE ORIGINAL CHEMS VERSION AS THIS IS A GOOD PLACE TO COMPARE A PHASE CHANGE TO A CHEMICAL CHANGE IN TERMS OF MAGNITUDE. USUALLY, THE RATIO OF ENERGIES IS BETWEEN 5:1 AND 10:1. STUDENTS DO THIS LAB IN PAIRS. ONE WILL DO THE COMBUSTION PART AND THE OTHER WILL DO THE PHASE CHANGE. THEY SHARE THEIR DATA FOR WRITE-UP PURPOSES.

DESCRIPTION OF HEAT1
----------- -- -----

SINCE HEAT1 IS AN ORIGINAL CHEM1 PROGRAM, IT HAS A SLIGHTLY DIFFERENT FORMAT. IT OFTEN REQUESTS MORE THAN ONE INPUT AT A TIME; THESE SHOULD BE INPUTED TOGETHER SEPARATED BY A COMMA. FOR PART I, IT BEGINS BY REQUESTING THE FOLLOWING IN ORDER:

THE WEIGHT OF THE CANDLE BEFORE AND AFTER BURNING (IN GRAMS)
NOTE: IF THE CANDLE WEIGHT AFTER BURNING IS NOT LESS THAN THE WEIGHT BEFORE BURNING, IT WILL PRINT AN ERROR MESSAGE AND THEN REQUEST NEW INPUTS FOR THE WEIGHT OF THE CANDLE BEFORE AND AFTER BURNING.

THE WEIGHT OF THE EMPTY CAN AND THE CAN AND WATER TOGETHER (IN GRAMS)

THE TEMPERATURE OF THE WATER BEFORE AND AFTER IN DEGREES CENTIGRADE.

THE FOLLOWING RESULTS ARE THEN PRINTED:

WEIGHT OF CANDLE BURNED
WEIGHT OF WATER HEATED
TEMPERATURE CHANGE OF THE WATER
THE NUMBER OF CALORIES USED TO WARM THE WATER
THE HEAT OF COMBUSTION OF THE CANDLE IN CALORIES/GRAM

NOTE ALSO THAT THE NUMBER OF CALORIES USED TO WARM THE WATER IS PRINTED AS WEIGHT OF WATER MULTIPLIED BY THE TEMPERATURE CHANGE; THE HEAT OF COMBUSTION IS PRINTED AS THE NUMBER OF CALORIES USED, DIVIDED BY THE WEIGHT OF THE CANDLE BURNED.

PART II WILL REQUIRE THE FOLLOWING INFORMATION.

THE WEIGHT OF THE EMPTY TEST TUBE AND THE TEST TUBE AND WAX (IN GRAMS)
NOTE: AGAIN, AN ERROR MESSAGE WILL BE PRINTED IF THE EMPTY TEST WEIGHS MORE THAN THE TEST TUBE AND WAX; AND THE QUESTION WILL BE REPEATED.

THE WEIGHT OF THE EMPTY BEAKER AND BOTH THE BEAKER AND WATER (IN GRAMS)

THE BEFORE AND AFTER WATER TEMPERATURES

THE RESULTS INCLUDE:

THE WEIGHT OF WAX
THE WEIGHT OF THE WATER
THE TEMPERATURE CHANGE OF THE WATER
THE NUMBER OF CALORIES USED TO WARM THE WATER
(THIS IS GIVEN AS THE WEIGHT OF THE WATER MULTIPLIED BY THE TEMPERATURE CHANGE.)
THE HEAT OF SOLIDIFICATION OF THE WAX
(THIS IS GIVEN AS THE NUMBER OF CALORIES USED, DIVIDED BY THE WEIGHT OF THE WAX.)

SAMPLE RUN OF HEAT1

```
HEAT1   01:52 PM        09-JUL-73
ENERGY OF COMBUSTION

NAME                    SECTION


WHAT WAS THE WEIGHT OF THE CANDLE BEFORE AND
AFTER BURNING (IN GRAMS)? 28.77,27.54
NOW, THE WEIGHT OF THE CAN EMPTY AND
THE CAN AND WATER TOGETHER (IN GRAMS)? 68.65,241.65
ALSO, I NEED THE TEMPERATURE OF THE WATER
BEFORE AND AFTER (DEGREES C)? 17.2,42.8

WEIGHT OF CANDLE BURNED =  1.23 G
WEIGHT OF WATER HEATED = 193 G
TEMPERATURE CHANGE OF WATER =  25.6 C
IT TOOK  193 * 25.6  OR  4979.4  CALORIES TO WARM THE WATER
THIS MEANS THE HEAT OF COMBUSTION OF THE CANDLE MATERIAL
WAS  4979.4 / 1.23  OR  4048.29  CALORIES PER GRAM

IN THE SECOND PART, WHAT WAS THE WEIGHT OF A
EMPTY TEST TUBE AND THE TEST TUBE AND WAX (IN GRAMS)? 21.6,32.33
THE EMPTY BEAKER AND BOTH THE BEAKER AND WATER? 97.2,227.5
ALSO, THE BEFORE AND AFTER WATER TEMPERATURES? 26.6,50.6

WEIGHT OF WAX =  10.73 G
WEIGHT OF WATER =  130.3 G
TEMPERATURE CHANGE OF WATER =  4 C
IT TOOK  130.3 * 4  OR  521.2  CALORIES TO WARM THE WATER
THIS MEANS THE HEAT OF SOLIDIFICATION OF THE WAX
WAS  521.2 / 10.73  OR  48.5761  CALORIES PER GRAM

AGAIN? NO
```

LAB AND COMPUTER HINTS PROGRAM 7

CHEMICAL EQUILIBRIUM

PRIOR TO LAB PRECALCULATE INITIAL CONCENTRATIONS OF FE AND SCN IN THE CLASSROOM. ALSO, EXPLAIN THE FORMAT THAT THE PROGRAM IS PRINTED OUT IN. DEPENDING ON THE TYPE OF CLASS, THE THE CALCULATIONS ARE USUALLY REQUIRED BY THE STUDENT PRIOR TO RUNNING THEIR PROGRAM AND THE PRINT OUT IS USED AS A CHECK FOR THEIR CALCULATIONS.

DESCRIPTION OF FESCN

THE ONLY INPUT FESCN REQUIRES IS THE RATIOS OF THE HEIGHTS OF THE LIQUID IN THE TEST TUBES. THE RATIO TAKES THE FORM:

$$\frac{\text{HEIGHT OF TEST TUBE 2}}{\text{HEIGHT OF TEST TUBE 1}}$$

SINCE THE RATIO OF TEST TUBE 1 TO 1 WILL ALWAYS BE 1.0, THIS RATIO IS NOT ENTERED. THE RATIOS OF THE OTHER TEST TUBES ARE ENTERED SEPARATED BY COMMAS. A TABLE IS THEN PRINTED WHICH CONTAINS FESCN, FE, AND SCN AT EQUILIBRIUM.

COLUMN AAAAA IS THE EXPRESSION $[FE^{+3}]*[SCN^{-1}]*[FESCN^{+2}]$

***** NOTE! THIS EXPRESSION IS TAKEN FROM THE FREEMAN TEXT.

COLUMN BBBBB IS THE EXPRESSION $[FE^{+3}]*[FESCN^{+2}]/[SCN^{-1}]$

COLUMN CCCCC IS THE EXPRESSION $[FE^{+2}]/[FESCN^{+3}]/[SCN^{-1}]$

THE PROGRAM CHOOSES THE BEST NUMERICAL RELATIONSHIP BASED ON THE STUDENT'S DATA.

SAMPLE RUN OF FESCN

```
CHEMICAL EQUILIBRIUM (FESCN)

NAME                                    SECTION

WHAT ARE YOUR 4 RATIOS? .98,.90,.78,.62

#  [FE] [SCN] RATIO [FESCN]   [FE]     [SCN]   AAAAAAAA BBBBBBBB CCCCCCCC
   INIT  INIT          EQUIL  EQUIL    EQUIL
1 0.1000 .001 1.000 0.00100 0.09900 0.00000 --------- --------- ---------
2 0.0400 .001 0.980 0.00098 0.03902 0.00002 1.45E-10  1.911980  1295.760
3 0.0100 .001 0.900 0.00090 0.01510 0.00010 1.58E-09  0.139980   596.020
4 0.0064 .001 0.780 0.00078 0.00582 0.00022 9.44E-10  2.119926   630.484
5 0.0026 .001 0.620 0.00062 0.00196 0.00038 4.66E-10  0.405631   624.351
A = 2.9132 00    B = 5.916E 02    C = 2.107E 00

C IS THE BEST CONSTANT NUMERICAL RELATIONSHIP


AGAIN? NO
```

LAB AND COMPUTER HINTS PROGRAM 8

ACID-BASE TITRATION (ACBAT1)

THIS LAB IS DONE INDIVIDUALLY AND THE SELECTION OF ACIDS FROM THE LAB GUIDE IS USED. ACIDS ARE PUT IN VIALS AND THEN, NUMBERED SO EACH STUDENT MAY KEEP THE VIAL AT HIS LAB POSITION. THE STANDARD ACID IS BEST TO BE NEAR 0.100 M. UNKNOWN BASES CAN BE MADE UP AS OUTLINED IN THE TEACHERS LAB GUIDE. BEST RESULTS SEEM TO BE OBTAINED WHEN A STUDENT HAS THREE CLOSE VALUES FOR PART I AND PART II. IT SEEMS BECAUSE OF THE TIME FACTOR THAT NOT ALL CLASSES GET TO PART III! THUS IT IS LEFT AS OPTIONAL IN THE PROGRAM.

NOTE THAT IN THE PROGRAM SAMPLE DATA RUN THAT THE STUDENT FOUND AN AVERAGE MOLECULAR WEIGHT OF 137 GRAMS PER MOLE OF UNKNOWN ACID. THIS IS WORK WELL DONE AS THE UNKNOWN WAS KHSO4 WHICH HAS A MOLECULAR WEIGHT OF APPROX. 136 GRAMS PER MOLE. RESULTS FOR THE VINEGAR SEEM TO USUALLY COME OUT LOWER THAN THE STANDARD 5%.

DESCRIPTION OF ACBAT1

THE FORMAT OF THIS PROGRAM IS SLIGHTLY DIFFERENT THAN THAT OF OTHER PROGRAMS. THE INFORMATION IS NOT DIVIDED INTO DATA AND CALCULATIONS. THE PROGRAM FIRST ASKS FOR THE NUMBER OF TRIALS OF BASE THAT ONE WISHES TO CALCULATE. THE FOLLOWING WILL THEN BE REPEATED, ONCE FOR EACH TRIAL:

WHAT IS THE MOLARITY OF THE STANDARD ACID?
WHAT VOLUME OF ACID IN ML WAS USED?
WHAT VOLUME OF BASE IN ML WAS USED?

THE PROGRAM THEN OUTPUTS THE MOLARITY OF THE BASE. WHEN THE MOLARITY OF THE FINAL TRIAL HAS BEEN CALCULATED, THE AVERAGE MOLARITY IS CALCULATED.

THE PROGRAM THEN PROCEEDS TO ASK FOR THE NUMBER OF TRIALS ONE WISHES TO CALCULATE FOR THE UNKNOWN ACID. THE FOLLOWING SEQUENCE WILL BE REPEATED, ONCE FOR EACH TRIAL:

MASS OF ACID TO BE USED IN THIS TRIAL
VOLUME IN ML OF THE BASE USED

THE PROGRAM THEN CALCULATES THE MOLECULAR WEIGHT OF THE ACID FOR THAT TRIAL.

AFTER ALL THE TRIALS HAVE BEEN RUN, IT WILL CALCULATE THE AVERAGE MOLECULAR WEIGHT OF THE ACID IN GRAMS.

THE PROGRAM THEN ASKS IF YOU WISH TO DO THE OPTIONAL PART OF THE LAB. IF THE ANSWER IS 'YES', THE PROGRAM PROCEEDS TO INFORM YOU THAT THE CALCULATIONS ARE DONE ASSUMING 1 ML OF VINEGAR = 1 GRAM. IT REQUESTS THE FOLLOWING INFORMATION:

MILLILITERS OF VINEGAR USED
MILLILITERS OF BASE USED

THE RESULT IS THE PERCENTAGE OF ACETIC ACID IN VINEGAR.

SAMPLE RUN OF ACDAT1

```
ACID-BASE TITRATION

NAME                                SECTION

HOW MANY TRIALS OF YOUR BASE DO YOU WISH TO CALCULATE? 2
WHAT IS THE MOLARITY OF YOUR STANDARD ACID? .104
WHAT VOLUME OF ACID IN ML DID YOU USE? 13.0
WHAT VOLUME OF BASE IN ML DID YOU USE? 7.0
MOLARITY OF BASE IS .193143 FOR TRIAL# 1
WHAT VOLUME OF ACID IN ML DID YOU USE? 10.0
WHAT VOLUME OF BASE IN ML DID YOU USE? 5.1
MOLARITY OF BASE IS .203922 FOR TRIAL# 2
THE AVERAGE MOLARITY OF BASE IS .198532

HOW MANY TRIALS FOR UNKNOWN ACID DO YOU WISH TO CALCULATE? 2
MASS OF ACID TO BE USED IN THIS TRIAL? .52
VOLUME IN ML OF BASE USED? 19.8
MOLECULAR WEIGHT FOR THIS TRIAL IS 132.284
MASS OF ACID TO BE USED IN THIS TRIAL? .55
VOLUME IN ML OF BASE USED? 19.4
MOLECULAR WEIGHT FOR THIS TRIAL IS 142.801
AVERAGE MOLECULAR WEIGHT OF ACID IN GRAMS IS 137.542

DO YOU WISH TO DO THE OPTIONAL PART OF THE LAB (YES OR NO)? YES
CALCULATIONS ARE DONE ASSUMING 1 ML VINEGAR=1 GRAM
ML VINEGAR USED? 5.0
ML BASE USED? 19.6
% ACETIC ACID IN VINEGAR IS 4.66918
```

LAB AND COMPUTER HINTS PROGRAM 9

MOLES OF CU, MOLES OF AG, AND MOLES OF ELECTRONS INVOLVED DURING ELECTROLYSIS (AGECU)

THIS LAB IS BEST DONE IN GROUPS BELAUSE OF EQUIPMENT AND COST OF REAGENTS. IF VARIABLE POWER SUPPLIES ARE AVAILABLE THEN THIS CAN REPLACE THE BATTERY AND RHEOSTAT FROM THE CIRCUIT DIAGRAM. PRE-CHECK EACH WIRING SET-UP AS MIS-WIRED SETUP IS COSTLY AND CAN HINDER MANY OTHER CLASSES FROM DOING THE EXPERIMENT. IF 30 MINUTES TIME IS NOT FEASIBLE, THEN 15 MINUTES WILL GIVE REASONALBE RESULTS.

BY NOW THE PROGRAM SHOULD BE VERY UNDERSTANDABLE TO THE STUDENTS. AGAIN, THE RESULTS SHOULD IMPROVE FOR THE AG:CU RATIO FROM LAB 7. MOST VALUES FOR THIS SEEM TO RANGE FROM 1.8 TO 2.1.

DESCRIPTION OF AGECU

THE FOLLOWING INFORMATION IS REQUESTED:

AMOUNT OF TIME CURRENT FLOWED IN SECONDS
THE INCREASE IN MASS IN GRAMS OF THE COPPER CATHODE
THE INCREASE IN MASS IN GRAMS OF THE SILVER CATHODE

THE FOLLOWING INFORMATION IS GIVEN AS OUTPUT:

MOLES OF ELECTRONS USED IN THIS EXPERIMENT
INCREASE IN MOLES AT THE CU CATHODE
INCREASE IN MOLES AT THE AG CATHODE
RATIO OF MOLES OF ELECTRONS TO MOLES OF CU
RATIO OF MOLES OF ELECTRONS TO MOLES OF AG
RATIO OF MOLES OF AG TO MOLES OF CU
THE INTEGER RATIO OF MOLES OF AG TO MOLES OF CU

SAMPLE RUN OF AGECU

MOLES OF COPPER, MOLES OF SILVER, AND MOLES OF ELECTRONS
DURING ELECTROLYSIS

NAME SECTION

DATA
AMOUNT OF TIME CURRENT FLOWED IN SECONDS IS? 1800.0
INCREASE IN MASS (GRAMS) OF CU CATHODE IS? 0.59
INCREASE IN MASS (GRAMS) OF AG CATHODE IS? 1.89

ANSWERS TO QUESTIONS
MOLES OF ELECTRONS USED IN THIS EXPERIMENT ARE .01872
MOLES OF INCREASE AT THE CU CATHODE ARE .929134E-2
MOLES OF INCREASE AT THE AG CATHODE ARE .175162E-1
RATIO OF MOLES OF ELECTRONS TO MOLES OF CU IS 2.01478
RATIO OF MOLES OF ELECTRONS TO MOLES OF AG IS 1.06872
RATIO OF MOLES OF AG TO MOLES OF CU IS 1.88522
INTEGER OF MOLES OF AG TO MOLES OF CU IS 2

COMPUTER PROGRAMS FOR CHEMISTRY EXPERIMENTS II

BY DALE C. REYNARD

(A DEL-MOD FUNDED PROJECT)
JUNE 26, 1973

EDITED AND REVISED BY OSAA: PROJECT DELTA
REVISION AUGUST 1973

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INTRODUCTION

THIS IS THE SECOND GROUP OF COMPUTER PROGRAMS DESIGNED TO ASSIST THE STUDENT IN WRITING UP LABORATORY EXERCISES. ALL PROGRAMS ARE FROM THE D. C. HEATH REVISION OF THE ORIGINAL CHEMS PROGRAM WITH THE EXCEPTION OF PROGRAM 7, A STUDY OF REACTION RATES, WHICH IS FROM THE FREEMAN VERSION OF CHEMS.

THE CROSS-REFERENCE INDEX HAS BEEN ENLARGED AND CERTAINLY SHOULD BE OF ASSISTANCE TO THE MANY USERS. IF THE TEXT USED IN YOUR CLASSES IS NOT INCLUDED IN THE LIST, THEN THE MATERIALS NEEDED ARE READILY AVAILABLE AT YOUR LOCAL DEL-MOD RESOURCE CENTER.

ANY ASSISTANCE NEEDED WITH THE COMPUTER OPERATION CAN BE HANDLED BY THE SCIENCE TEACHER IN CHARGE OF THIS OPERATION AT YOUR SCHOOL. IN ADDITION THERE ARE SEVERAL CAPABLE STUDENTS ASSOCIATED WITH PROJECT DELTA WHO ARE VERY WILLING TO BE OF ASSISTANCE TO THE TEACHER. TO IDENTIFY THESE STUDENTS YOU SHOULD CONSULT THE MATHEMATICS TEACHER IN CHARGE OF THE COMPUTER IN YOUR SYSTEM.

FOR EACH PROGRAM THERE WILL BE A PAGE DEVOTED TO LAB AND COMPUTER HINTS WHICH WILL INCLUDE TYPICAL STUDENT DATA AND AN ACTUAL RUN OF THIS DATA. THE LAST THREE PROGRAMS ARE JUST A FEW OF THE POSSIBLE PROGRAMS WHICH MAY BE RUN USING PLOT03.

THE PROGRAMS MAY BE USED FOR THE STUDENTS TO GAIN A "HANDS-ON" EXPERIENCE OR MAY BE USED BY THE TEACHER AS A NUMERIC CHECK ON LAB REPORTS.

INSTRUCTIONS FOR GAINING ACCESS TO THE COMPUTER ARE SIMPLE.

1) LOG-IN (SEE PROJECT DELTA'S USER'S MANUAL.)

2) AFTER THE TERMINAL RESPONDS WITH READY, YOU WILL TYPE RUN $'PROGRAM NAME' SUCH AS RUN $PLOT03.

3) ENTER DATA AS REQUESTED BY THE PROGRAM.

4) WHEN YOU ARE FINISHED, LOG-OUT. (SEE PROJECT DELTA'S USER'S MANUAL.)

IT IS HOPED THAT THE PROGRAMS WILL PROVIDE YOUR STUDENTS WITH A LEARNING EXPERIENCE ON THE COMPUTER TERMINAL.

WITHOUT THE HELP OF THE ABLE PERSONNEL OF PROJECT DELTA THIS GROUP OF PROGRAMS WOULD BE VERY LIMITED. SPECIAL THANKS TO MARK LINTON, A BRANDYWINE HIGH SCHOOL STUDENT, FOR HIS ASSISTANCE IN CONSTRUCTING THE PLOT03 PROGRAM.

NOTE: ALTHOUGH THESE PROGRAMS HAVE BEEN TESTED BY THE AUTHOR NO WARRANTY, EXPRESS OR IMPLIED, IS MADE BY THE AUTHOR, OR BY DSAA: PROJECT DELTA AS TO THE ACCURACY OR FUNCTIONING OF THE PROGRAMS OR RELATED MATERIAL AND NO RESPONSIBILITY IS ASSUMED BY THESE PARTIES IN CONNECTION THEREWITH.

CROSS-REFERENCE LIST FOR PROGRAMS

PROGRAM TITLE	CODE	LAB MANUAL REFERENCE						
		1	2	3	4	5	6	7
IRON-COPPER SULFATE REACTION	CUFEM1		6					19-4
ENERGY NEEDED TO MELT ICE	ICEM1		13				9*	
HEAT OF RX FOR THE COMBUSTION OF MG	HCMG1		27					
HEAT OF REACTION	HESS1	13	26	12-1	21	17	10	23-3
WARMING & COOLING OF A PURE SUBSTANCE	PLOT03	3	12	6-1		3	15	
FORMULA OF A PRECIPITATE	PLOT03	10	16		12	12		
STUDY OF REACTION RATES	PLOT03	14	26	13-1	22	18	27	21-3

LAB MANUAL REFERENCE CHART

1 CHEMS, CHEMISTRY: AN EXPERIMENTAL APPROACH, FREEMAN, 63

2 DAVIS,MCNAB, CHEMISTRY: EXPERIMENTS AND PRINCIPLES, HEATH, 68

3 TOON & ELLIS, FOUNDATIONS OF CHEMISTRY, HOLT,RINEHART & WINSTON, 68

4 FERGUSON & SCHMUCKLER, LAB. INVEST. IN CHEMISTRY, SILVER BURDETT, 70

5 TELLEFSEN,DIETZ,PARRY,STEINER, CHEMISTRY EXPER FOUND, PRENTICE-HALL, 70

6 CARMICHAEL,HAINES,SMOOT, LABORATORY CHEMISTRY, MERRILL, 71

7 COTTON,DARLINGTON & LYNCH, CHEMISTRY: AN INVEST. APPROACH, HOUGHTON MIFFLIN, 73

TO USE THE ABOVE REFERENCE LIST LOCATE YOUR LABORATORY OR TEXT USED BY NUMBER AND REFER TO THE FIRST LISTING OF THE PROGRAMS ON THIS PAGE.

AN ASTERISK MEANS THAT THE LAB CAN BE USED WITH SOME ALTERATIONS.

IF THE LABORATORY MANUAL OR TEXT YOU USED IS NOT LISTED, THEN CONSULT THE D.C. HEATH REVISION OF THE ORIGINAL CHEMS COURSE TO SEE IF A PARTICULAR PROGRAM WOULD BE SUITABLE FOR USE.

IRON-COPPER SULFATE REACTION (CUFEM1)

THIS IS A LESS EXPENSIVE LAB TO RUN FOR DETERMINING THE MOLE RATIO THAN THE TRADITIONAL SILVER-COPPER EXPERIMENT. THE ACTUAL MOLE RATIO GIVES OVERALL IMPROVED RESULTS THAN THE SILVER-COPPER LAB.

THIS LAB IS A GOOD FOLLOW-UP ON SIGNIFICANT FIGURES AND IS SO CONSTRUCTED THAT STUDENTS ARE ASKED TO ROUND ALL ANSWERS TO THE PROPER NUMBER OF SIGNIFICANT FIGURES BEFORE INTERPRETING THEIR DATA. VALUES FOR THE MOLAR MASSES OF IRON AND COPPER ARE 55.8 AND 63.5 GRAMS PER MOLE RESPECTIVELY.

TYPICAL STUDENT DATA IS AS FOLLOWS:

MASS OF EMPTY BEAKER	37.55 G
MASS OF WEIGHING PAPER	1.03 G
MASS OF PAPER & IRON FILLINGS	3.05 G
MASS OF BEAKER & DRY PRODUCT	39.90 G

THE RESULTS ARE:

MASS OF THE PRODUCT
MOLES OF IRON
MOLES OF COPPER
MOLE RATIO OF IRON TO COPPER

SAMPLE RUN OF CUPEM1

IRON-COPPER SULFATE REACTION

NAME SECTION

DATA

MASS OF EMPTY BEAKER IN GRAMS IS	? 37.55
MASS OF WEIGHING PAPER IN GRAMS IS	? 1.03
MASS OF IRON FILLINGS AND PAPER IS	? 3.05
MASS OF BEAKER AND DRY PRODUCT IS	? 39.9[illegible]

CALCULATIONS

MASS OF PRODUCT IS	2.35
MOLES OF IRON IS	.362007E-1
MOLES OF COPPER IS	.370079E-1
MOLE RATIO OF IRON TO COPPER IS	.97814

ROUND EACH ANSWER TO THE PROPER NUMBER OF
SIGNIFICANT FIGURES USING YOUR DATA.

ENERGY NEEDED TO MELT ICE (ICER1)

THIS LAB IS PERFORMED USING STYROFOAM CUPS AS CALORIMETERS WHICH ARE USUALLY AVAILABLE FROM YOUR SCHOOL CAFETERIA. RESULTS OF THIS LAB ARE USUALLY VERY ACCURATE WITH REFERENCE TO THE ACCEPTED VALUE FOR THE HEAT OF FUSION OF WATER. CARE SHOULD BE EXERCISED IN THE HANDLING OF THE ICE PRIOR TO STUDENT USAGE SUCH AS STORING IN A FREEZER OR AN ICE CONTAINER UP TO THE TIME OF USAGE. PROBLEMS DEVELOP IF THE ICE IS MELTING AT ROOM TEMPERATURE PRIOR TO USAGE.

ASSUME ONE CALORIE EQUALS ONE GRAM OF WATER RAISED ONE DEGREE CENTIGRADE. NEGLECT VOLUME DIFFERENTIAL OF WATER AND ICE. ASSUME ONE GRAM OF WATER EQUALS ONE MILLILITER OF WATER.

TYPICAL STUDENT DATA IS GIVEN BELOW:

VOLUME OF WATER BEFORE ICE IS ADDED	120 ML
VOLUME OF WATER AFTER ICE IS ADDED	156 ML
TEMPERATURE BEFORE ICE IS ADDED	44 DEG C
TEMPERATURE AFTER MELTING	1 DEG C

THE RESULTS ARE:

MASS OF ICE MELTED
TEMPERATURE CHANGE OF THE BATH
ENERGY USED FOR 100 G OF ICE
ENERGY USED FOR 1 G OF ICE
ENERGY PER MOLE OF ICE MELTED
KILOCALORIES USED TO MELT ICE

SAMPLE RUN OF ICER1

```
ENERGY NEEDED TO MELT ICE

NAME                                    SECTION

ENTER ALL MASSES IN GRAMS
      ALL VOLUMES IN MILLILITERS, AND
      ALL TEMPERATURES IN DEGREES CENTIGRADE
REMEMBER 1 CAL = 1 GRAM OF WATER RAISED 1 DEGREE CENTIGRADE
      OR 1 = 1 CAL/(1 G * 1 DEGREE C)

DATA
----
WHAT IS THE VOLUME OF WATER BEFORE AND AFTER THE EXPERIMENT? 100,156
WHAT IS THE TEMPERATURE BEFORE AND AFTER THE EXPERIMENT? 40,1

RESULTS
-------
Q1  MASS OF ICE MELTED = 56.0 G

Q2  TEMP CHANGE OF THE BATH = 43.0 DEGREES

Q3  ENERGY USED FOR 100 G OF ICE = 7676.6 CALORIES

Q4  ENERGY USED FOR 1 G OF ICE =  76.8 CALORIES

Q5  ENERGY PER MOLE OF ICE MELTED = 1382.1 CAL/MOLE

Q6  H2O(S) +  1.38 KCAL = H2O(L)
```

HEAT OF REACTION FOR THE COMBUSTION OF MAGNESIUM (HCMG1)

THIS IS A VERY REWARDING LAB BECAUSE OF THE STABLE RESULTS OBTAINED BY STUDENTS. AGAIN, IT MAY BE USED PER PAIR OF STUDENTS OR AS A CLASS DEMONSTRATION USING AVERAGE CLASS RESULTS FOR DATA.

IT IS USEFUL TO DISPENSE MG RIBBON BY LENGTH AND HAVE THE STUDENTS MEASURE THE LENGTH OF MG RIBBON USED. PRIOR TO THE LAB, MEASURE THE MASS OF A METER OF MG RIBBON AND GIVE THIS CONSTANT TO THE STUDENTS. CHEMICAL SUPPLIERS HAVE DIFFERENT SIZES OF MG RIBBON, THUS, THIS VALUE SHOULD BE CHECKED PERIODICALLY. STYROFOAM CUPS ARE USED AS CALORIMETERS. USUALLY, 30 CM. OF MG RIBBON IS PLENTY TO GIVE GOOD RESULTS. CARE MUST BE USED BY STUDENTS (EASIER IF WORKING IN PAIRS) TO MAKE SURE ALL THE MG RIBBON IS REACTED IN RX. 3. THIS CAN BE DONE BY COILING THE MG INSIDE THE STYROFOAM CUP. IN RX. 4 THE VALUE FOR THE HEAT OF FORMATION OF LIQUID IS TAKEN FROM THE TEXT OR APPROPRIATE TABLE. THIS IS A VERY GOOD LAB TO INTRODUCE THE LAW OF ADDITIVITY OF HEATS.

TYPICAL STUDENT DATA IS GIVEN AS FOLLOWS:

CONSTANT FOR MASS PER METER OF MG RIBBON	.715 G/M
LENGTH OF MG RIBBON USED IN METERS	.356 M
CHANGE IN TEMPERATURE IN RX. 3	11.500 DEG C
VOLUME OF SOLUTION IN RX. 3	100.000 ML
MASS OF MGO USED IN RX. 2	1.000 G
VOLUME OF SOLUTION USED IN RX. 2	100.000 ML
CHANGE IN TEMPERATURE IN RX. 2	8.930 DEG C

CHECK THE SAMPLE RUN FOR THE RESULTS GIVEN.

SAMPLE RUN OF HCMG1

HEAT OF REACTION FOR THE COMBUSTION OF MAGNESIUM

NAME SECTION

DATA

MASS IN GRAMS OF MAGNESIUM RIBBON PER METER? .715
LENGTH OF MG RIBBON USED IN METERS (RX,3)? .356
CHANGE IN TEMP. OF SOLUTION IN DEGREES CENTIGRADE (RX,3)? 11.5
VOLUME OF SOLUTION HEATED IN ML (RX,3)? 100
MASS OF MAGNESIUM OXIDE USED IN GRAMS (RX,2)? 1.00
VOLUME OF SOLUTION HEATED IN ML (RX,2)? 100
CHANGE IN TEMP. OF SOLUTION IN DEGREES CENTIGRADE (RX,2)? 8.9

RESULTS

RX NO.	HEAT KCAL	MOLES	KCAL/MOLE	CHANGE IN H
2	.89	.248139E-1	35.867	-35.867
3	1.15	.104749E-1	109.786	-109.786

RX,2 35.867 + MGCL2 + H2O(L) = MGO + 2HCL
RX,3 MG + 2HCL = MGCL2 + H2 + 109.786
RX,4 H2 + 1/2 O2 = H2O(L) + 68.3

RX,1 35.867 + MG + 1/2 O2 = MGO + 178.086
MG + 1/2 O2 = MGO + 142.219

CHANGE IN H1 = -142.219

HEAT OF REACTION (HESS1)

THIS LAB CAN BE DONE INDIVIDUALLY, IN PAIRS OR INDIVIDUALLY BUT WITH THE TABULATION OF AVERAGE CLASS DATA FOR A SINGLE RUN ON THE TERMINAL. THIS LAB IS DESIGNED TO PROVE THE LAW OF ADDITIVITY OF HEATS. VOLUMES PRESCRIBED IN THE LAB MANUAL ARE HALVED AND STILL YIELD VERY ACCEPTABLE RESULTS. THIS REDUCES THE VOLUMES OF SOLUTIONS NECESSARY, CONSIDERABLY. STRESS THE TIME FACTOR IN RELATION TO WATER VAPOR ABSORPTION OF THE SODIUM HYDROXIDE PELLETS. IT IS NOT NECESSARY TO WEIGH EXACTLY EVEN GRAMS, BUT AN ACCURATE MEASURE OF MASS ON A CENTIGRAM BALANCE IS DESIRABLE. ASSUME 1 ML OF EACH SOLUTION EQUALS 1 GRAM OF SOLUTION. THE PROGRAM IS DESIGNED FOR MOLAR SOLUTIONS OF 0.25 M HCL IN RX. 2 AND 0.50 M NAOH AND HCL IN RX. 3.

TYPICAL STUDENT DATA FOR THIS LAB IS AS FOLLOWS:

IN RX. 1

MASS OF NAOH PELLETS	0.98 G
VOLUME OF WATER USED	100.00 ML
TEMPERATURE CHANGE	2.2 DEG C

IN RX. 2

MASS OF THE NAOH PELLETS	1.03 G
VOLUME OF 0.25 M HCL USED	100.00 ML
TEMPERATURE CHANGE	5.6 DEG C

IN RX. 3

VOLUME OF 0.50 M HCL USED	50.00 ML
VOLUME OF 0.50 M NAOH USED	50.00 ML
TEMPERATURE CHANGE	5.6 DEG C

CHECK THE SAMPLE RUN FOR THE RESULTS SUPPLIED.

SAMPLE RUN OF HESS1

HEAT OF REACTION

NAME SECTION

ENTER ALL TEMPERATURES IN DEGREES CENTIGRADE,
ALL MASSES IN GRAMS, AND
ALL VOLUMES IN MILLILITERS.

ASSUME 1 ML OF EACH SOLUTION = 1 GRAM.

DATA

FOR RX 1, ENTER TEMP. CHANGE, VOL. CHANGE, AND MASS NAOH? 2.2,100,.98
FOR RX 2, ENTER TEMP. CHANGE, VOL. CHANGE, AND MASS NAOH? 5.6,100,.99
FOR RX 3, ENTER TEMP. CHANGE, VOL. OF NAOH, VOL. OF HCL? 3.6,50,50

RESULTS

QUESTION 1

REACTION NO.	TEMP CHANGE	HEAT(CAL) RELEASED	MOLES NAOH	ENERGY KCAL/MOLE
1	2.2	220	.0245	8.97959
2	5.6	560	.02475	22.8571
3	3.6	360	.025	14.4

QUESTION 2
H1 = -8.97959
H2 = -22.8571
H3 = -14.4

QUESTION 5
H2 = (H1 + H2) * .52245

QUESTION 6
% DIFF = -2.28572

QUESTION 7
4.00 G OF NAOH YIELDS (4 / .98) * 220 OR 897.959
H1 WOULD REMAIN THE SAME.

INSTRUCTIONS FOR USING THE GRAPHING PROGRAM (PLOT03)

THIS PROGRAM WILL PLOT SETS OF ORDERED PAIRS. SEVERAL CHEMISTRY LABS REQUIRE A GRAPHICAL REPRESENTATION OF A SET OF ORDERED PAIRS OR SETS OF ORDERED PAIRS. IN A LABORATORY ORIENTED CLASS THIS PROGRAM IS MOST USEFUL. THREE EXAMPLES OF THE USAGE OF THIS PROGRAM ARE INCLUDED. HOWEVER, ANY LABORATORY EXPERIMENT WHERE ORDERED PAIRS ARE TAKEN FOR DATA, CAN BE GRAPHICALLY REPRESENTED BY THIS PROGRAM.

EXPLANATION OF THE MATERIAL NECESSARY AT HAND TO USE THE PROGRAM IS BELOW. THE NUMBER IN BRACKETS IS USED TO IDENTIFY THE EXPLANATION OF THAT PART OF THE COMPUTER PRINT-OUT.

```
PLOT PROGRAM

ENTER NO. OF GRAPHS?                          (1)
?                                             (2)
?                                             (3)
MAJOR HEADING FOR GRAPH?                      (4)
UNITS: DOWN,ACROSS?                           (5)
LEFT LIMIT, RIGHT LIMIT, INCREMENT?           (6)
UPPER LIMIT, LOWER LIMIT, INCREMENT?          (7)
```

---

(1) ENTER THE NUMBER OF DIFFERENT SETS OF DATA YOU WANT PLOTTED ON THE SAME GRAPH. THE PROGRAM WILL PRINT A MAXIMUM OF SIX (6) SETS. AFTER TYPING IN THE NUMBER, HIT THE RETURN KEY.

(2) A QUESTION MARK NOW MEANS ENTER THE ORDERED PAIRS FOR THE FIRST SET OF DATA. ONE ENTERS AN X-VALUE FOLLOWED BY A COMMA AND THE CORRESPONDING Y-VALUE FOLLOWED BY A COMMA AND THE NEXT ORDERED PAIR. EXAMPLE: 1,2,2,4,3,6. NOTE THAT THERE IS NOT A COMMA AFTER THE LAST NUMBER. AFTER ENTERING THE FIRST SET OF DATA HIT THE RETURN KEY.

(3) THIS QUESTION MARK MEANS TO ENTER THE NEXT SET OF DATA IN THE SAME MANNER AS THE FIRST SET.

(4) ENTER THE TITLE OF THE GRAPH.

(5) TYPE IN THE UNITS FOR THE Y-AXIS, THEN A COMMA, AND THE UNITS FOR THE X-AXIS.

(6) LEFT LIMIT MEANS THE SMALLEST VALUE OF X TO BE USED OR IN MANY CASES A VALUE OF ZERO (0) IS USED. RIGHT LIMIT MEANS THE LARGEST VALUE OF X THAT IS TO BE USED. INCREMENT MEANS THE UNIFORM SPACING TO BE USED ALONG THE X-AXIS. AN X OR Y VALUE MUST BE EXACTLY A VALUE THAT IS INCLUDED IN THE INCREMENT TO BE PLOTTED. THE MAXIMUM LIMIT FOR THE HORIZONTAL AXIS IS 60 SPACES. AFTER ENTERING EACH VALUE, SEPARATED BY A COMMA, HIT THE RETURN KEY.

(7) UPPER LIMIT MEANS THE MAXIMUM OR LARGEST Y-VALUE THAT IS TO BE PLOTTED. LOWER LIMIT MEANS THE MINIMUM Y-VALUE THAT IS TO BE PLOTTED OR IN MANY CASES THE VALUE IS ZERO. INCREMENT MEANS THE UNIFORM SPACING FACTOR TO BE USED. THERE IS NO LIMIT TO THE NUMBER OF SPACES FOR THE Y-AXIS. REMEMBER THAT THE FEWER THE NUMBER OF INCREMENTS USED THE LESS THE AMOUNT OF COMPUTER TIME THAT IS USED.

IN ORDER TO SAVE COMPUTER TIME IT IS USUALLY DESIRABLE TO ROUND ORDERED PAIRS SUCH THAT INCREMENTS ARE KEPT FEW IN NUMBER. IN MANY CASES THIS DOES NOT DISTORT THE GRAPH BUT IMPROVES THE RELATIONSHIP. ALSO, WHERE SIMPLE UNIFORM DILUTIONS ARE USED AS IN CONCENTRATIONS OF SOLUTIONS THEN, CONCENTRATION WOULD BE MORE DESIRABLE TO BE THE X-AXIS. REFER TO THE FOLLOWING THREE PROGRAMS TO SEE HOW DATA PAIRS ARE ROUNDED.

DIFFERENT SYMBOLS ARE USED FOR EACH SET OF ORDERED PAIRS. THE FIRST SET IS SYMBOLIZED BY AN ASTERISK (*), THE SECOND SET BY AN X (X), THE THIRD SET BY A PLUS SIGN (+), THE FOURTH SET BY A PERIOD (.), THE FIFTH SET BY AN 'OH' (O), AND THE SIXTH SET BY A DOLLAR SIGN ($). NOTE: IF TWO VALUES OF Y ARE EQUAL WHEN USING TWO OR MORE SETS OF ORDERED PAIRS THE COMPUTER WILL PRINT OUT A SLASH MARK (/), WHICH WILL BE SEEN IN THE NEXT PROGRAM.

LAB AND COMPUTER HINTS — PROGRAM 5

WARMING & COOLING BEHAVIOR OF A PURE SUBSTANCE (PLOT03)

THIS LAB USES PARADICHLOROBENZENE AS THE PURE SUBSTANCE, BUT CANDLE WAX MAY BE SUBSTITUTED IN ITS PLACE. BEST RESULTS ARE GAINED BY TAKING TEMPERATURE READINGS AT 30 SECOND INTERVALS. STRESS TO STUDENTS THE IMPORTANCE OF THE STARTING WATER BATH TEMPERATURES AS PRESCRIBED IN THE LAB MANUAL. TIME IS SAVED BY NOT RECORDING THE WATER BATH TEMPERATURES AT INTERVALS BUT BY BEING AWARE AS THE BATH TEMPERATURE NEARS THE TEMPERATURE OF THE PURE SUBSTANCE.

READINGS TO THE NEAREST DEGREE CENTIGRADE WERE TAKEN AND ONLY THE BOXED IN AREA WAS USED FOR GRAPHING. TWO PRINT-OUTS OF THIS LAB ARE INCLUDED TO SHOW THE RESULTS OF CHANGING THE INCREMENT FOR THE X-AXIS.

TYPICAL STUDENT DATA FOLLOWS:

TIME (MIN.)	WARMING (DEG C)	COOLING (DEG C)
0.0	22	66
0.5	27	64
1.0	33	61
1.5	40	59
2.0	\ 45 /	57
	--	
2.5	50	54
3.0	52	55
3.5	53	53
4.0	53	53
4.5	53	53
5.0	54	55
5.5	56	52
	--	
6.0	/ 59 \	50
6.5	--	46
7.0	--	44

AFTER THE STUDENT HAS RUN THE PROGRAM, HE SHOULD CONNECT THE POINTS, EXCLUDING EXTRANEOUS POINTS. THE RESULT SHOULD BE A SMOOTH CURVE.

SAMPLE RUN OF PLOTPS

```
***** NOTE: FOR THE X-AXIS A 0.5 INCREMENT IS USED.

PLOT PROGRAM; ENTER NO. OF GRAPHS? 2
? 2,57,2.5,54,3,53,3.5,53,4,53,4.5,53,5,53,5.5,52,6,50
? 2.5,50,3,52,3.5,53,4,53,4.5,53,5,54,5.5,56
MAJOR HEADING FOR GRAPH(S)? WARMING & COOLING CURVES OF A PURE SUBSTANCE
UNITS: DOWN,ACROSS? DEGREES CENTIGRADE,MINUTES
LEFT LIMIT,RIGHT LIMIT, INCREMENT? 1.5,6.5,.5
UPPER LIMIT,LOWER LIMIT,INCREMENT? 58,49,1

              WARMING & COOLING CURVES OF A PURE SUBSTANCE

SYMBOLS: *,X
DOWN:   DEGREES CENTIGRADE    58 TO 49 IN STEPS OF 1
ACROSS: MINUTES               1.5 TO 6.5 IN STEPS OF .5

            ............
+5.800000E 01
+5.700000E 01 *
+5.600000E 01          X
+5.500000E 01
+5.400000E 01   *      X
+5.300000E 01    *///*
+5.200000E 01    X     *
+5.100000E 01
+5.000000E 01   X       *
+4.900000E 01
            ............
```

SAMPLE RUN OF PLOT#3

```
***** NOTE!  FOR THE X-AXIS A 0.25 INCREMENT IS USED.

PLOT PROGRAM; ENTER NO. OF GRAPHS? 2
? 2,57,2.5,54,3,53,3.5,53,4,53,4.5,53,5,53,5.5,52,6,50
? 2,5,50,3,52,3.5,53,4,53,4.5,53,5,54,5.5,56
MAJOR HEADING FOR GRAPH(S)? WARMING & COOLING CURVES OF A PURE SUBSTANCE
UNITS! DOWN,ACROSS? DEGREES CENTIGRADE,MINUTES
LEFT LIMIT,RIGHT LIMIT, INCREMENT? 2,7,.25
UPPER LIMIT,LOWER LIMIT,INCREMENT? 57,49,1

            WARMING & COOLING CURVES OF A PURE SUBSTANCE

SYMBOLS! *,X
DOWN!   DEGREES CENTIGRADE   57 TO 49 IN STEPS OF 1
ACROSS! MINUTES               2 TO 7 IN STEPS OF .25

          ....................
+5.700000E 01*
+5.600000E 01                X
+5.500000E 01
+5.400000E 01  *          X
+5.300000E 01    * / / / *
+5.200000E 01    X         *
+5.100000E 01
+5.000000E 01  X             *
+4.900000E 01
          ....................
```

LAB AND COMPUTER — PROGRAM 6

FORMULA OF A PRECIPITATE (PLOT03)

THIS EXPERIMENT IS A GREAT IMPROVEMENT OVER THE ORIGINAL CHEMS VERSION. IN THE D.C. HEATH VERSION THE AMOUNTS OF PRECIPITATES WHEN PLOTTED AGAINST MILLIMOLES OF LEAD IONS PINPOINTS TO THE STUDENTS WITHOUT A DOUBT THE CORRECT MOLE RATIO FOR THE LEAD IODIDE FORMULA. ONLY THE GRAPH FOR THIS LAB IS INCLUDED IN THIS PROGRAM AS STUDENTS SHOULD BE ABLE TO HANDLE THE CALCULATIONS EASILY; OR THE NUMBER OF MILLIMOLES OF LEAD AND IODIDE IONS MAY BE CALCULATED AS A CLASS PROJECT.

USUALLY STUDENTS FIND THE LAB EASIER TO PERFORM OVER A TWO DAY PERIOD. THE FIRST DAY IS DEVOTED TO MAKING THE DESIRED SOLUTIONS AND THEIR MIXING, AND THE MEASURE OF THE RELATIVE HEIGHTS OF THE PRECIPITATE. THE SECOND DAY, THE STUDENTS ARE EMPLOYED IN FILTERING THE PRECIPITATES AND DRYING. INSTRUCT THE STUDENTS TO USE AS FEW WASHINGS AS NECESSARY SINCE THIS WILL IMPROVE THEIR RESULTS. THE TIME FACTOR IS REDUCED IF THE STUDENTS WORK THE FIRST DAY IN PAIRS. THEN, THE SECOND DAY FOUR PAIRS OF STUDENTS COMBINE PRECIPITATES TO SPEED UP FILTERING. ALSO, ENOUGH LEAD IODIDE WILL BE PRESENT TO GIVE GOOD GRAPHICAL REPRESENTATION.

TYPICAL STUDENT DATA IS INCLUDED BELOW AND NOTE THE COLUMN FOR THE ROUNDED VALUE OF PRECIPITATE MARKED BY AN ASTERISK (*). BY DOING THIS ADDED MANIPULATION IT WILL SAVE COMPUTER TIME WHEN THE INCREMENT FOR THE Y-AXIS IS REDUCED FROM A 0.01 TO A 0.1 GRAM INCREMENT.

TEST TUBE NO.	LEAD IONS (MILLIMOLES)	PRECIPITATE (GRAMS)	PRECIPITATE (GRAMS)
1	0.5	0.92	0.9
2	1.0	1.84	1.8
3	1.5	2.84	2.8
4	2.0	2.32	2.3
5	2.5	1.84	1.8
6	3.0	1.40	1.4
7	3.5	0.92	0.9
8	4.0	0.46	0.5

SAMPLE RUN OF PLOT88

```
PLOT PROGRAM; ENTER NO. OF GRAPHS? 1
? .5,.9,1,1.8,1.5,2.8,2.0,2.3,2.5,1.8,3.0,1.4,4.5,.9,4.0,.5
MAJOR HEADING FOR GRAPH(S)? GRAMS OF PREC VS. MILLIMOLES OF LEAD IONS
UNITS: DOWN,ACROSS? GRAMS,MILLIMOLES
LEFT LIMIT,RIGHT LIMIT, INCREMENT? .5,4,.25
UPPER LIMIT,LOWER LIMIT,INCREMENT? 3,.5,.1

                GRAMS OF PREC VS. MILLIMOLES OF LEAD IONS

SYMBOLS: *
DOWN:   GRAMS  3 TO .5 IN STEPS OF .1
ACROSS: MILLIMOLES          .5 TO 4 IN STEPS OF .25

              ...............
+3.00000E 00
+2.90000E 00
+2.80000E 00     *
+2.70000E 00
+2.60000E 00
+2.50000E 00
+2.40000E 00
+2.30000E 00       *
+2.20000E 00
+2.10000E 00
+2.00000E 00
+1.90000E 00
+1.80000E 00   *      *
+1.70000E 00
+1.60000E 00
+1.50000E 00
+1.40000E 00           *
+1.30000E 00
+1.20000E 00
+1.10000E 00
+1.00000E 00
+9.00000E-01*             *
+8.00000E-01
+7.00000E-01
+6.00000E-01
+5.00000E-01                *
            ...............
```

LAB AND COMPUTER HINTS PROGRAM 7

A STUDY OF REACTION RATES (PLOT33)

THE IODINE CLOCK REACTION IS A VERY EASY LAB TO PERFORM AND HAS BEEN A FAVORITE FOR YEARS. THIS LAB IS DONE IN PAIRS AND TO GAIN ACCURATE RESULTS THE ORIGINAL CHEMS VERSION IS USED. IF ONE WISHES TO SEE THE EFFECT OF A CATALYST, THEN SUPPLY THE STUDENTS WITH A SMALL DROPPING BOTTLE OF 0.01 M CUSO4 SOLUTION AND ADD TWO DROPS TO EACH SOLUTION TRIED IN PARTS I AND II. THIS IS A GOOD FOLLOW-UP AS A CLASS DEMONSTRATION. THE STUDY OF TIME VS. TEMPERATURE IS BEST ACHIEVED BY ASSIGNING TEMPERATURE RANGES TO INDIVIDUAL PAIRS OF STUDENTS. THEN THE DATA IS COMBINED FOR CLASS RESULTS. PRIOR TO THE LAB, IT IS IMPORTANT TO DISCUSS THE LAB AND HAVE THE STUDENTS PRECALCULATE THE CONCENTRATIONS IN PART I.

IF THE INITIAL SOLUTION UPON MIXING REQUIRES MORE THAN 25 SECONDS FOR THE COLOR CHANGE, THEN REFER TO THE 'FREEMAN TEACHERS GUIDE' TO ALLEVIATE THIS PROBLEM.

USUALLY, THIS IS AN EXCELLENT TIME TO RELATE TO THE STUDENTS WAYS OF MAKING A LINEAR RELATIONSHIP FOR A COMPLEX (SECOND OR THIRD DEGREE EQUATION) CURVE. A TECHNIQUE OFTEN EMPLOYED AT THIS TIME, IS TO HAVE THE STUDENTS PLOT A GRAPH OF TIME VS. RECIPROCAL CONCENTRATION (1/CONC) OR USE SEMILOG PAPER FOR THE PLOT OF TIME VS. LOG CONCENTRATION. BOTH OF THESE IDEAS CAN BE USED WITH AN ADVANCED CLASS, WITH A HIGH DEGREE OF SUCCESS.

INCLUDED IN EACH TABLE ARE VARIABLES THAT HAVE BEEN ROUNDED SO THAT A MORE WORKABLE INCREMENT CAN BE USED FOR THE X OR Y AXIS. THIS COLUMN IS DESIGNATED BY AN ASTERISK (*).

TYPICAL STUDENT DATA IS:

PART I CONCENTRATION VS.. TIME
(TEMPERATURE CONSTANT)

CONCENTRATION (MOLES/LITER)	TIME (SEC)	TIME* (SEC)
0.010	24	25
0.009	29	30
0.008	35	35
0.007	45	45
0.006	56	55
0.005	71	70
0.004	91	90
0.003	148	150
0.002	--	--

***** NOTE: A 5 SEC Y-AXIS INCREMENT CAN NOW BE USED.

PART II TIME VS.. TEMPERATURE
(CONCENTRATION CONSTANT)

TIME (SEC)	TEMPERATURE (DEG C)	TEMPERATURE* (DEG C)
10	39	40
12	34	35
14	29	30
16	25	25
20	20	20
35	9	10

***** NOTE: A 5 DEG C INCREMENT CAN NOW BE USED.

SAMPLE RUN OF PLOT3

```
PLOT PROGRAM; ENTER NO. OF GRAPHS? 1
? .01,25,.009,30,.008,35,.007,45,.006,55,.005,70,.004,90,.003,150
MAJOR HEADING FOR GRAPH(S)? CONC VS. TIME  (TEMP CONSTANT)
UNITS: DOWN,ACROSS? SECONDS,MOLES PER LITER
LEFT LIMIT,RIGHT LIMIT, INCREMENT? .001,.011,.0005
UPPER LIMIT,LOWER LIMIT,INCREMENT? 150,20,5

                    CONC VS. TIME  (TEMP CONSTANT)

SYMBOLS: *
DOWN:   SECONDS                 150 TO 20 IN STEPS OF 5
ACROSS: MOLES PER LITER         .001 TO .011 IN STEPS OF .0005

              ....................
+1.50000E 02     *
+1.45000E 02
+1.40000E 02
+1.35000E 02
+1.30000E 02
+1.25000E 02
+1.20000E 02
+1.15000E 02
+1.10000E 02
+1.05000E 02
+1.00000E 02
+9.50000E 01
+9.00000E 01       *
+8.50000E 01
+8.00000E 01
+7.50000E 01
+7.00000E 01         *
+6.50000E 01
+6.00000E 01
+5.50000E 01           *
+5.00000E 01
+4.50000E 01             *
+4.00000E 01
+3.50000E 01               *
+3.00000E 01                 *
+2.50000E 01                   *
+2.00000E 01
              ....................
```

SAMPLE RUN OF PLOT01

```
PLOT PROGRAM; ENTER NO. OF GRAPHS? 1
? 10,40,12,35,14,30,16,25,20,20,36,10
MAJOR HEADING FOR GRAPH(S)? TIME VS. TEMP  (CONC CONSTANT)
UNITS: DOWN,ACROSS? DEGREES CENTIGRADE,SECONDS
LEFT LIMIT,RIGHT LIMIT, INCREMENT? 10,40,2
UPPER LIMIT,LOWER LIMIT,INCREMENT? 50,5,5

                    TIME VS. TEMP  (CONC CONSTANT)

SYMBOLS: *
DOWN:   DEGREES CENTIGRADE    50 TO 5 IN STEPS OF 5
ACROSS: SECONDS               10 TO 40 IN STEPS OF 2

              ...............
+5.00000E 01
+4.50000E 01
+4.00000E 01*
+3.50000E 01 *
+3.00000E 01  *
+2.50000E 01   *
+2.00000E 01    *
+1.50000E 01
+1.00000E 01          *
+5.00000E 00
            ...............
```